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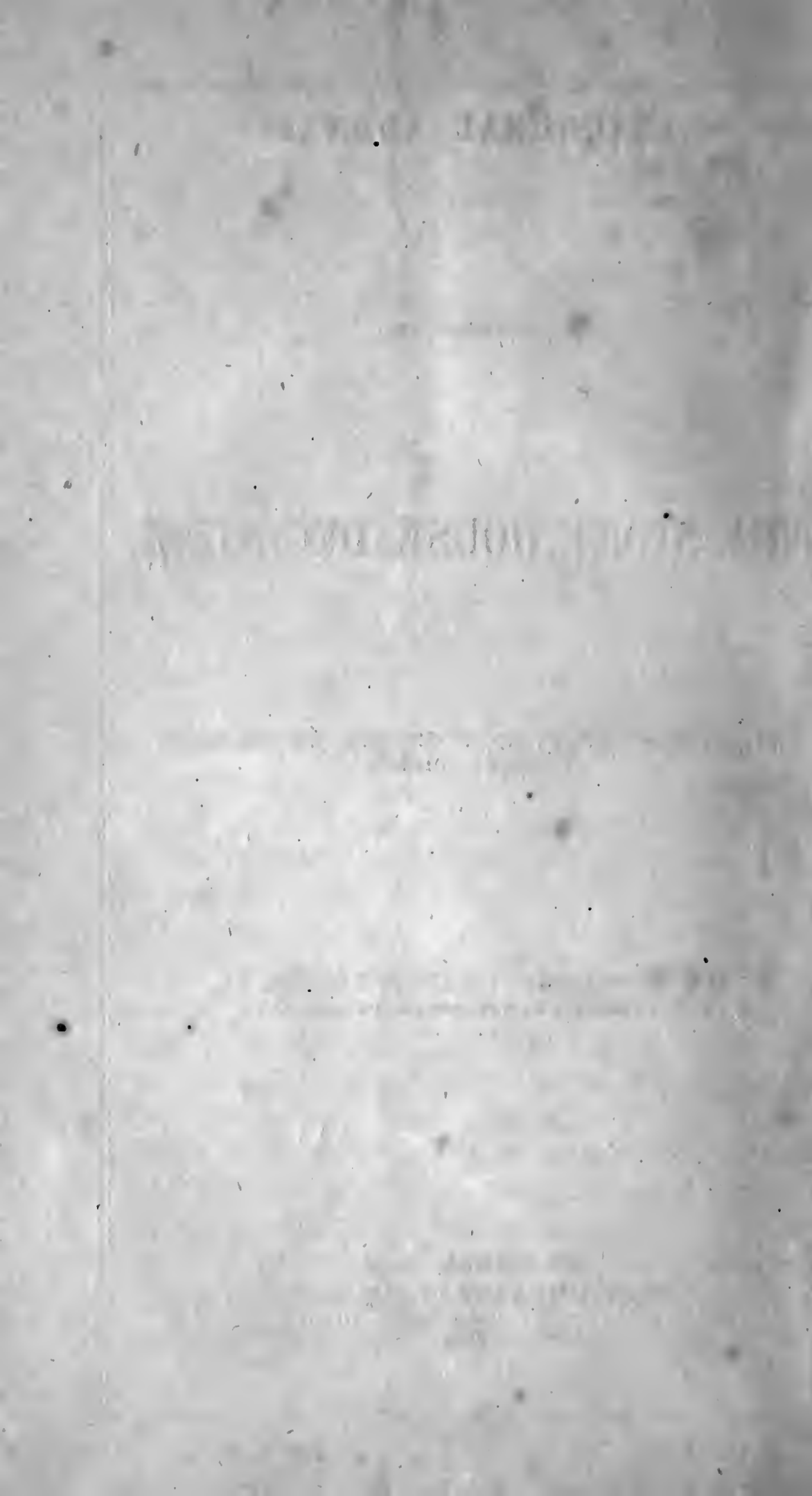
BY ORDER OF THE BOARD OF TRUSTEES OF THE SOUTH
CAROLINA COLLEGE.

BY JOSEPH LECONTE, M. D.,

PROFESSOR OF CHEMISTRY, MINERALOGY AND GEOLOGY.

COLUMBIA, S. C.:
STEAM-POWER PRESS OF R. W. GIBBES.

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THE
JOURNAL OF THE
AMERICAN MEDICAL ASSOCIATION

CHICAGO, ILL., MAY 1, 1914

TO THE EDITOR: I have the honor to acknowledge the receipt of your issue of April 28, 1914, and to thank you for the interest and attention which you have given to the work of the American Medical Association. The issue contains a number of articles of interest and value, and I am sure that it will be found to be a most useful and interesting addition to the literature of the profession. I am, Sir, very respectfully,
Yours very truly,
J. H. HARRIS, Secretary.

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If we attentively examine the history of science, we will find that the order of development of the principal departments has been, Mathematics, Mechanics, Astronomy, Physics, Chemistry, Biology, and finally Geology. Now, it is instructive to observe that this is also precisely the order of their increasing complexity. Mathematics is the simplest of all sciences, since it includes only ideas of *number and quantity*. Mechanics, Astronomy and Physics, in addition to ideas of number and quantity, include also those peculiar to themselves, viz: ideas of *force*. Chemistry, in addition to the preceding, includes also ideas connected with *chemical affinity*. Biology, in addition to the preceding, also ideas of *life*; and Geology, in addition to all the preceding, ideas of *historic development*. Thus, it appears, that the order of development of these great subdivisions of science was not arbitrary or fortuitous, but necessary, because founded upon the natural relation which exists amongst them. It was but the natural evolution from the simple to the complex, from the general to the special, which marks the progress of all development. It was impossible that Mechanics, Astronomy and Physics, should take even the form of science until, first, mathematics was somewhat matured. Thus, also, Chemistry must await the development of Physics, Biology of Chemistry, and Geology of all the rest. Thus they have been solidly and

regularly built up; each department when sufficiently matured forming the foundation upon which the next was raised. Together they form a column of which Mathematics is the pediment, and Geology the capital; or rather a magnificent temple of which Mathematics forms the solid foundation and Geology the heaven-pointing spire—the most wonderful and perfect work which human genius has yet erected in honor of Deity. Its foundations deeply laid by the Greek Geometers—its massive walls steadily built up by the physical philosophers of the sixteenth and seventeenth centuries—its towers and pinnacles, the crowning glory of the whole work, being even now finished by the Biologist and Geologists of the present day; this wonderful work has continued steadily to unfold its beauty, unaffected by the fluctuations of human history, the plan unchanging and unchangeable. Is there anything like this amongst human works? Is there anything which so nearly approaches the type of the Divine? In science alone the collective human mind seems to work in conscious harmony with eternal laws.

It was absolutely necessary, then, that Geology should have been the latest developed of all the sciences, for the problems which she proposes are the most complex and difficult in all science, and require the aid of all other departments. The Geologist, too, must be accomplished in all departments of science, or else he can never be anything more than a collector or a smatterer. He must be thoroughly grounded in Mechanics and Physic, or how shall he reason successfully on the upheaval of continents, the formation of mountain chains, the dynamics of earthquakes and volcanoes, the laws of

currents, &c. He must be equally acquainted with Chemistry, for the disintegration of rocks to form soils, the consolidation of sediments to form rocks, the deposits of springs, the formation of coal and mineral veins, are all chemical questions. Still more necessary, if possible, to him is an acquaintance with organic science, for organic remains are the very hieroglyphs, in which the history of the earth is written. Besides all these, there are other and still more difficult problems, peculiar to herself, involving her own fundamental idea of historic development, e. g. the laws which have governed this history, the plan which has presided over it; in short, its significance, its philosophy. It is this very difficulty and complexity of the problems presented, this almost universal culture required of her votaries, which constitutes the greatest obstacle in the way of real progress in this science. I know it is looked upon by many as simple and easy. I know many suppose that industry in the collection of fossils, and perseverance in the exercise of a good memory, are all that is necessary to make an accomplished Geologist. But this is a sad and a very pernicious error. In so extensive a science, collectors of materials must be very numerous, but philosophic generalizers are correspondingly few. In so vast an edifice fetchers of brick and stone and mortar are innumerable, but heaps of brick and stone and mortar do not constitute a temple. The one may be accumulated by the human hand, the other can be constructed only by the human mind, and in this case only by genius of the highest order. In fact, so great is the difficulty of the work, that no one has yet lived who can be looked up to with confidence as the master

builder in this science. No one has yet been able to sketch the outlines of this noble work with a hand so firm and decided that all shall labor in harmony and mutual confidence, and the work shall thenceforward proceed with steadiness and certainty.

Now, as surely as the order of complexity and dependence among the sciences, which I have mentioned above, necessitates a corresponding order of historic development, so surely does it also necessitate the same order in the culture of each individual. In this, as well as in many other instances, the history of the race is the type of the history of the individual. In every complete scientific course therefore, Mathematics must be first, and Geology last in order of time. They form as it were the two opposite poles of a scientific course. If we diminish or destroy the one or the other, the equilibrium is overthrown, the completeness of the course is destroyed. In the one case we imitate the folly of him who builds his house upon sand or straw, in the other of him who exhausting his means in laying deep the foundation, built nothing thereon.

There are two, and only two, general methods of reasoning used by the human mind in the attainment of truth, viz: the inductive and the deductive methods, the synthetic and the analytical, the generalizing and the logical. All the so-called methods of reasoning are but subdivisions of these. Let us compare the principal departments of science with reference to the use of these two methods. Mathematics commences with universal self-evident truths, and its course of reasoning is therefore entirely deductive or logical. As soon as we leave this science, however, induction commences. The fun-

damental laws of Mechanics, as self-evident as they now seem to us, were only established by the original founders of this science after a short course of observation and experiment, and therefore of true induction. Since that time this science, like Mathematics, has been entirely deductive. In the case of Astronomy the course of induction was much longer. The Astronomer climbed the hill of induction step by step, established one general truth after another, until Newton reached the highest platform, and made the last generalization. Since then, all has again been deduction, the mere expansion and necessary application of the formula of universal gravitation. In Physics and Chemistry, the inductive course has been still longer and more tedious, before general principles were established, upon which it was safe to base deductive reasoning. Last of all in Biology and Geology, the process has been almost entirely one of generalization. One inductive step after another has been taken, one general truth after another has been established, but as yet we cannot be said to have attained a truth so general that it shall comprehend the whole science, or so firm that we can reason from it with logical certainty and precision. Prospect after prospect has enchanted us with their beauty, but as yet they are only partial views. The field is so vast that we must climb still higher before we can get a comprehensive view of the whole, and take it in at one glance.

Thus we see that the order we have so often insisted upon is also the order of increasing predominance of the inductive method, and the inverse order of the employment of the deductive. Geology is the extreme type of the inductive, as Mathematics is of the deductive.

Geology cultivates almost exclusively the faculty of generalization, while Mathematics cultivates exclusively the analytical or logical faculty. Thus they become again the complements of each other, the opposite poles of the educational course.

Again: From a purely abstract point of view, Mathematics may be said to be the most general, the most comprehensive, the most universal of all sciences. Her dominion is universal, her laws are necessary and independent even of the existence of matter. All sciences are dependent upon her, and all their laws are conditioned by the supremacy of her laws. As we pass up the scale of sciences we find the dominion of these becoming more and more limited, and their laws more and more special. In a hierarchy of sciences, therefore, Mathematics is the chief priestess, while the other departments rank lower and lower, are more and more subordinate in the order so often named. If, however, we turn from the abstract to the human point of view, the case is precisely reversed. As a human study, as a means of human culture, Mathematics is the most special and limited of all, while Biology and Geology become the most general. From this point of view Geology becomes the high priestess, while all other sciences are subordinates ministering to her wants, and among these subordinates, Mathematics is evidently the lowest.

Thus it is evident that the relative rank of the sciences depends entirely upon the point from which we view the subject. Mathematics is the lowest in type, but the highest in development; Geology the highest in type, but the lowest in development. They bear to one another somewhat the same relation which Greek Art

with its simplicity, its perfect beauty, its symmetry, its limitedness, bears to modern art with its variety, its youthful vigor, its strength, its grandeur, its boundlessness. The former is more satisfying, the latter more inspiring—the one induces more content and repose, the other creates more strength and enthusiasm.

Thus, in every way we find these two extremes the natural complements of each other. Mathematics practising exclusively the deductive, Geology almost exclusively the inductive; Mathematics cultivating the analytical faculty, Geology the faculty of generalization; Mathematics giving clearness, distinctness, but at the same time narrowness of vision; accuracy, ingenuity, dexterity but not strength, profundity but not comprehensiveness. Geology on the other hand tends to largeness of view and power of combination, but at the same time often to want of clearness of vision, and therefore to want of certainty.

If we represent the finite known amidst the infinite unknown by a circle of light in the midst of darkness, then, in the case of Mathematics, (dealing with the most limited number of ideas and cultivating the most limited number of faculties, but these in the most perfect manner), this circle of light is small but of the most intense brightness, and passes at one step from the most perfect light to the most perfect darkness, from perfect knowledge to absolute ignorance. In all other sciences, however, the light shades by imperceptible gradations into darkness. The area of perfect day is surrounded by a region more or less extensive of twilight. This zone of twilight increases in breadth as we ascend the scale of sciences, narrow in Physics, broader in Chemistry and

broadest in Biology and Geology. Now, it is on these outskirts of knowledge that the strongest and bravest spirits, the pioneers in Science love to dwell, for it is here that the inductive, the generalizing faculty finds its proper field of activity. Induction reclaims the darkness and converts it into twilight. Deduction, following more or less close behind, converts the twilight into perfect day. And thus under their combined effort the circle of knowledge widens. The twilight region is the region of discussion, of controversy, of *hypotheses*; the area of perfect light is the region of acknowledged fact and true *theories*. Now, this faculty of penetrating the darkness, of seeing in the dim twilight, is beyond all doubt the noblest faculty of the human mind. This will be the more evident when we recollect that in many departments most nearly connected with the highest human interests, as for instance ethical and political science, the whole area is still twilight. There is not a single principle universally acknowledged. If in these important departments we are compelled to dwell in twilight, how important it is to cultivate the faculty of distinguishing objects with tolerable certainty.

If I have succeeded thus far in making myself clear, I think it cannot be denied that any course of education which commences with Mathematics is radically bad, distorting and contracting the mind unless it passes upwards through all the sciences and particularly unless an equal attention is paid to the more complex departments of Biology and Geology. All the evil effects which have been attributed to the study of science arise from stopping short of this point. Precisely similar evil effects, and from a similar cause, may be observed in

other departments of education. A complete course of education is naturally divisible into three subordinate courses. The first commencing with Mathematics, passes upward through all the sciences; and terminates with Geology; the second commences with ancient languages, and passes upward through all literature and art; the third commences with metaphysics, and terminates with political and social philosophy. Now in each of these courses we observe the same antagonism, the same polarity between the extremes. Everything I have said concerning the complementary qualities and tendencies of Mathematics and Geology, apply with equal force to Languages as compared with Art, and to Metaphysics as compared with Political Philosophy. Languages and Metaphysics form the basis of a literary and philosophic culture as Mathematics does of a scientific culture. But Languages and Metaphysics as well as Mathematics, tend to narrow and contract the mind by cultivating exclusively the analytical and critical powers, unless counteracted by the comprehensiveness, the breadth of view and the generalizing tendency of the higher departments of each course, viz: of Art and Political Philosophy. Here, also, unless the opposite poles are equal, the mental balance is destroyed. Thus it evidently follows that either of these courses fully and consistently carried out, forms a better education—i. e., more completely and symmetrically develops the mental faculties than an attempt at *all* but a confinement of the mind, upon a plea of thoroughness, to the lower members of each series. A completed wing of a building is better than the whole foundation unfinished, for the wing is at least habitable, at least serves the purposes of rational existence.

But it will be objected that this limiting effect of a partial course upon the mind is more strikingly displayed in the scientific course than in either of the others. Beyond all doubt this is true. No study is so limiting and contracting to the mind as the study of mathematics alone. No knowledge is half so superficial, trifling and shallow, so completely marks the charlatán, as the pretended knowledge of the higher and more complex departments of Biology and Geology, without a thorough basis of knowledge in the lower and simpler departments of Mathematics and Physics. But this, so far from being an objection, is the strongest argument in favor of a full scientific course; for it is the necessary result of the more complete organization of this course, of the regularity with which it is built up one department upon another, of the more complete differentiation of the educational function of the different departments. A scientific course, as I have already attempted to show, must be regarded as an organized unit, and it is a law of life that the more complete the organization, the more limited the function of each part—the more complete the organized unit, the more imperfect is each part when separated from its connection with the whole—the higher the *life* the more certainly is death the result of division.

I have thus far spoken of Geology, and compared it with other sciences, as a means of *training* the mind, of exercising its faculties and hardening its muscles, of giving it strength and beauty of form and symmetry of proportion, in other words as a necessary element in a gymnastic course. I wish next to compare it with other sciences not as a means of training, but as a means of *developing* the mind; not as hardening the muscles

but as causing its *growth* ; not as giving exercise but as furnishing the *food* upon which it grows and thrives, viz : the food of noble ideas and exalted conceptions ; as kindling the imagination and exciting noble emotion ; for the man of science is not only a builder of a great temple but must be a worshipper therein.

In this the noblest function of science, there are two departments which stand out beyond all others—viz : Astronomy and Geology. We have all been accustomed to look upon *Astronomy* as the most magnificent of sciences—as more than all others extending the bounds of human intellectual vision. But I am perfectly confident that when the age has grasped as firmly, and apprehended as clearly, the fundamental idea of Geology as it has already done that of Astronomy, all will agree with me in thinking, that the former is not one whit behind the latter in the overwhelming grandeur of its conceptions. Let us then compare these two noble sciences. Let us attempt to vindicate the claims of Geology to stand beside Astronomy in the very first rank of sciences, as twin sisters, distinguished from all others by superior dignity and beauty.

There are two conditions of material existence, Space and Time. We cannot conceive of material existence except under these two conditions. Now, the peculiar province of Astronomy is Space, as that of Geology is Time. Other Sciences may have to do with space, limited space, a portion of space, but it belongs to Astronomy alone to deal with *infinite* space. So also there are other sciences which necessarily deal with limited time, but it is the peculiar prerogative of Geology to deal with *infinite* Time. As Astronomy is limited in time to the

present epoch, or, in fact, to about two thousand years, but unlimited in space; so Geology is limited also in space to the surface of the earth, but unlimited in time. As Astronomy measures her distances by billions of *miles*, or millions of earth radii, so Geology her times by millions of *years*—i. e., of earth revolutions. As the Astronomer takes the radius of the earth as a base line wherewith to measure the dimensions of the Solar System, so the Geologist takes the present geological epoch and causes now in operation, as a *time*-measuring rod, with which to estimate the length of the tertiary period. As the Astronomer becoming more bold as he ascends, takes the diameter of earth's orbit as a line wherewith to measure the distances of the fixed stars, or even dares to estimate the probable distance of the remotest nebula; so the Geologist, no less daring, takes the tertiary period as a rod wherewith to measure approximatively the almost inconceivable lapse of time represented by the secondary rocks, or even dares to cast his telescopic glance back into the dim nebulosity of the remotest Palaeozoic period. Finally, as the Astronomer when telescopic vision fails, still speculates, though filled with awe, concerning the infinite unknown abyss of space beyond; so also the Geologist when mile-stones are no longer visible, when fossils and stratified rocks fail, still peers with wondering gaze backward and strives to pierce the darkness beyond—still believes that all which he sees or can see is but a fragment of the infinite abyss of time. Overwhelmed, appalled, he shrinks back and remembers that his own mind, so daring, so arrogant, so apparently limitless, is also but a fragment of the infinite intelligence.

“Thus while Astronomy fills the regions of the universe with objects, Geology fills the regions of infinite duration with events. As Astronomy carries us upwards by the relations of Geometry, Geology carries us backwards by the relations of cause and effect. As Astronomy steps from a point of the universe by a chain of triangles, so Geology steps from epoch to epoch of the earth’s history by a chain of mechanical and organic laws. If one depends on the axioms of Geometry, the other depends on the axiom of causation.” In a single word, the realm of Astronomy is the universe of space, that of Geology the universe of Time. The one peoples her universe with space worlds, the other hers with creations—Time worlds.

The object of all science is to establish universality of law. Harmony in the midst of apparent confusion—unity in the midst of diversity—unity of force amidst diversity of phenomena (physical science), or unity of plan in the midst of diversity of expression, (natural science); in a word, the unity of Deity in the multiplicity of nature. Now, it is the peculiar province of Astronomy to establish this universality of law, this unity of Deity throughout all space, as it is of Geology throughout all time. Astronomy shows that the same force which controls the falling of a stone governs the motions of the heavenly bodies; so, also, Geology shows that the changes through which each animal passes in its embryonic development are similar to that through which the whole earth and its inhabitants have passed in its Geological history—that the same mind which conducts the one has presided through all time over the other. If Astronomy, more than all other sciences, illustrates that sublime attri-

bute of Deity, his *omnipresence* or *unchangeableness in space*, Geology, more than all other sciences illustrates that other sublime attribute of Deity, his *immutability*, or *unchangeableness in time*.

There are in the history of science two eras which more than all others strike the imagination, and fill the mind with wonder, or rather I should say, two *moments*, the greatest in the intellectual history of the human race. They are those in which were born in the mind of man the fundamental ideas of Astronomy and Geology, the ideas of infinite space and infinite time containing other worlds and other creations.

You have all probably thought of the sublimity of that moment when the idea of infinite space peopled with worlds like our own, first thoroughly entered the mind of man. You have all probably shared in imagination the ecstasy of Galileo, as gazing with awe through the first telescope, the phases of Venus and the Satellites of Jupiter suddenly revealed to him the existence of other worlds besides his own. Before that pregnant moment our own world was *alone* in the universe. Sun, moon and stars, were but satellites to the earth. Astronomy was but the geometry of the heavens, the geometry of the curious lines which these wandering fires traced upon the crystalline concave of the skies. In an instant the great fundamental idea of modern Astronomy was born in the mind of Galileo. In an instant man's intellectual vision is infinitely extended, but his own world, before so great, has shrunk into an atom in the midst of infinite space; a younger and comparatively insignificant member of a great family of worlds.

We have all been accustomed to look upon this as the grandest moment in the intellectual history of man. But there is another moment less known, or if known, less thought of, because less understood and appreciated, but not less grand. It is that in which was born in the mind of man, the fundamental idea of Geology, infinite time containing successive creations; in which the idea of other time-worlds besides our own entered the mind of the aged Buffon.

For many years, indeed centuries, it had been observed that organic remains, particularly marine shells, might be found far inland, and even high up the slopes of mountains. There was much speculation among scientific men as to the origin of these shells. They were attributed by some to the deluge, by others more truly to the gradual and permanent changes in the relative level of sea and land. But no one for a moment supposed that they belonged to a period anterior to the present epoch. Some may have supposed that they were extending the known limits of the present epoch; that they were discovering new *continents* in the *ocean* of time; but did not dream that these were the evidences of a *new world*, of a distinct creation in the infinite *abyss* of time. Buffon himself had taken active part in these discussions. Finally, near the end of the last century, and in the evening of his great and long life, a large number of these remains, both marine shells and mammalian vertebrates, larger than he had ever examined before, were placed at his disposal and subject to his inspection. To his astonishment he found them all without exception different from species now inhabiting the earth. In that moment, in the mind of the venerable Buffon, suddenly,

like Minerva from the head of Jove, was born the idea of infinite time containing successive creations. In an instant, man's intellectual vision was again infinitely extended, but his own world again dwindled into a single day in the geological history of the earth. The whole future of Geology was seen in the vision of that moment. Filled with awe, the old man, then over eighty years of age, published his discovery. In a kind of sacred frenzy he spoke of the magnificence of the prospect, and prophesied of the future glories of this new science, which he was, alas! too old to pursue. Thus to the last, his dying hand pointed the way, and his dying voice kindled the enthusiasm of those whom he could no longer lead.

Picture for a moment to yourself the aged Buffon, thus gazing in rapture, silent and alone, upon this new world suddenly opened to his intellectual vision. I cannot help comparing him to Moses of old on the top of Pisgah. Like Moses, he had reached the extreme verge of mortal life. Like him he stood upon a mount, raised far above the rest of the world by the eminence of his intellectual position. Like him he gazed with sacred solemn joy, mingled with sadness, upon a new world, a promised land which he was forbidden to enter; and like him also he died there upon the mount, prophesying the future glories of the new land, and calling upon his followers to enter in and take possession.

But it will be objected that the rank of a science depends not only upon the dignity of its subjects, but also, in no small degree, upon the certainty of its conclusions; and that in this respect Astronomy is far superior to Geology. But even here the superiority of Astronomy has

been vastly exaggerated. Astronomy has its hypotheses and uncertainties as well as Geology, and on the other hand Geology has its certainties as well, and as many as Astronomy. Only it has happened in this, as in many other cases, that the hoary head, the wrinkled brow and known wisdom of age, has given false dignity to its errors and follies, while the wildness of youth has discredited its wisdom. The certainties of the old Astronomy has given an appearance of truth to its wildest hypotheses, while the hypotheses of the young Geology has unjustly thrown some discredit upon her truest theories and most certain facts. The certainties of Astronomy are the form, size, weight, distance and relative position of her space-worlds. Her uncertainties are their climate, physical geography, and more than all, their inhabitants animal and vegetable. The certainties of Geology are the climate, physical geography, and more than all, the inhabitants animal and vegetable, of her Time-worlds: her uncertainties are their relative size and distance. It is seen, then, that the certainties of the one are precisely the uncertainties of the other. Which then are the nobler, the certainties of Astronomy or those of Geology? Is it more noble to know the relative size and position of worlds in Space and Time, or to be acquainted with the beings which form their crowning glory? Or, if we compare their uncertainties, which are the most uncertain? The uncertainties of Astronomy, viz: the inhabitants of her space-worlds lie entirely beyond the limits of the attainable, while the uncertainties of Geology—i. e., the size and distance of her time-worlds, not only lie distinctly within the limits of the attainable, but have already been in some instances approximatively attained.

It would lead me too far to pursue this train of thought, suffice it to say, that in both cases that which was most important is also most certain, while what is most uncertain can be of little use for us to know. The highest glory of man is to pursue science without direct and immediate reference to its usefulness; to love truth for its own sake, and because it is the emblem of Divine wisdom: but it is God's merciful good pleasure where *all is unattainable*, to make that most attainable which shall contribute most to our material comfort.

If next we compare Geology with Astronomy, or in fact with all other sciences, in its bearings on Natural Theology, we shall find, not only an equality but an immense superiority on the part of Geology.

In comparing modern with ancient or even mediæval civilization, nothing is more striking or more significant than the difference in the manner in which Nature is viewed in relation to man. The spirit of the older civilizations tended to exalt man in his own estimation and to degrade Nature, while that of modern civilization tends to humiliate man by insisting on his own insignificance in comparison with the greatness of Nature. In Art this is seen in the gradual but constant increase in the contemplation of Nature, both in Painting and Poetry. In Science it is still more distinctly seen in the amazing progress in the physical and natural sciences. Landscape painting, whether on canvass or in poetry, seems to be peculiar to modern civilization. The Greek, it seems, was incapable of appreciating or understanding that love of Nature for its own sake, so characteristic of the modern mind—a love entirely irrespective of its subserviency to

human uses, which in fact is all the more passionate when she is most rugged and forbidding. I believe that it may be asserted that the modern passion for wilderness and mountain, of rock and crag, of cloud and storm, would be unintelligible to an ancient Greek. Every Homeric landscape intended to be beautiful consists of shady groves with bubbling fountains, green meadows and waving corn-fields. The Greek ideal garden, with its rows of leeks and vines, corresponds accurately with our kitchen garden. Nature was delightful to him only in its subservience to human uses. The infinite, the divine in Nature was hidden from his eyes, or only took the human form of Nymphs and Dryads. The Greek philosopher, too, despised Nature too much to become her pupil. He arrogated to himself the power of interpreting Nature by examining the workings of his own mind—he dared to impose upon Nature his own laws. Any other method was considered beneath the dignity of the human mind. Gradually, however, the mind of man has passed from the study and contemplation of itself to the study and contemplation of Nature. We believe this was a necessary, but cannot believe it to be a final change. When by the study and contemplation of Nature, a solid basis is laid for philosophy, the human mind will again return to the study and contemplation of *itself* as the greatest of Nature's works.

Now, it has already been seen that among the most efficient agents in bringing about this great and necessary change, has been the sciences of Astronomy and Geology. Nothing has tended so much to humiliate the pride of man as the recognition of the astounding fact that his

habitation, his world, is but an *atom* among millions of similar atoms in the boundless realms of space, and that his *Time*, the life of his race, is but a day in the immeasurable cycle of geological changes.

But there is this great difference between the two sciences, that while Astronomy leaves man thus humiliated, prostrate and hopeless, Geology lifts him up and restores him to his dignity. While Astronomy gives no evidence of the superiority of the Earth to other heavenly bodies, or of man above other possible material intelligences; gives no hint of the superior dignity of our world among other space-worlds; Geology most distinctly declares the superior dignity of our Time-world, and of our race among all other Time-worlds and their races. She teaches unmistakeably that there has been a gradual course of preparation for the present epoch—that there is an unity of plan in the whole system of Time-worlds—that in a certain sense they are all satellites of ours—that they are all bound together by a force, that force the plans of the Almighty, and its centre the present epoch. Thus man becomes the centre of the universe of Time. Thus, also, by analogy we are led to suspect that there may be a similar unity in the system of space-worlds also, and that ours may and probably does enjoy a superiority, if not in size, at least in organization, and therefore in the intelligence of its inhabitants. Thus man's dignity is restored, or rather I should say, dignity is given in place of pride. "Pride goeth before a fall," but dignity comes after.

The effect of Physical Science in humiliating, yea, even degrading man, is admirably expressed by that most

worldly of poets, Pope. In his beautiful survey of the universe, speaking of its Maker, he says, He

“Sees with equal eye as God of all,
A hero perish or a sparrow fall,
Atoms or systems into ruin hurled,
And now a bubble burst and now a world.”

I cannot conceive anything more utterly dreadful and hopeless, more utterly antagonistic to the religious spirit, than the philosophy of this passage. And yet this is a perfect expression of the tendency of all physical science until the advent of Geology. Do we not then owe a debt of gratitude to Geology for again restoring man to his true, and I might add, his Scriptural position as the crowning glory of the material universe?

Again. To make one more comparison. There was a time, and that not many years ago, when the battleground of Faith and Infidelity was situated in the domain of metaphysical science. Such was the infidelity of Hume and Voltaire. This form of infidel philosophy has well nigh passed away. The atheist, the acute, ingenious, hair-splitting sceptic of the last century, “is a well nigh extinct species of Philosopher.” He may be studied as a fossil but not feared as an enemy. Like the huge Saurians of the secondary period, they may astonish by their gigantic proportions and the cruel sharpness of their weapons, but they will return no more to trouble us with their hideous presence. The course of creation and Providence knows no backward movement. Those well meaning but ill-advised friends of religion, who are still directing their metaphysical batteries against this philosophy, are wasting their strength in attacking old castles, formidable strongholds indeed in their time, but

long ago dismantled. Meanwhile, the enemy taking advantage of their misdirected zeal, are even now making reprisals in an entirely different quarter. The battleground now, is not the metaphysical but the physical sciences. The enemy now, is not the Atheism, the negative Philosophy of the last age, but the pantheism and the positive material Philosophy of the present age. Here, then, at the very moment when the philosophical world was oscillating between the extremes of French materialism and German pantheism—at the very moment when Infidelity had reached its acme and faith its lowest ebb—at a time when the pride of human reason demanded, and the weakness of human faith required no longer metaphysical but physical evidence—at this very moment, as if sent expressly on a divine mission, Geology comes forward and gives positive, indisputable physical evidence not only of intelligence, but of *creative* intelligence, not only of Deity, but of a Deity, personal and independent of his works, and not only so, but of the miraculous exercise of creative power, over and over again, thousands of times in the history of the earth.

It may be laid down as a great Palaeontological law without exception, *that species have been introduced in full perfection, remained unchanged during the term of their existence*, and therefore died in full perfection; that new species have been introduced in every case by substitution and never by transmutation. The appearance of each species upon the arena of life, suddenly and in its full perfections, is in itself a proof of the personality of Deity which defies all cavilling; and when we recollect that this argument is repeated and receives strength for every individual species thus introduced, the accumulated

force is overwhelming. To use the beautiful and familiar illustration of Paley: "A watch is found upon a barren heath. How came it there?" Metaphysicians, time out of mind, have been battling without success to decide this apparently simple question. One side contends, very naturally, that it was put there by its maker, or at least that its contrivance shows that it must have had a maker; the other contends that this is only a superficial view of the subject; that as it seems to have the power of reproducing itself *ad infinitum*, there is no reason why its genealogy may not be traced backwards *ad infinitum*—that since the form and contrivance seems as far as natural laws are concerned to be *eternal*, there is no reason why the same form and contrivance may not have existed from all eternity. Just at this stage of the argument, Geology steps forward and settles the question forever. Both of these infidel positions she overturns at one blow. Species do not reproduce *ad infinitum*, nor have they existed from eternity—but like individuals they have a term of existence—they both commence and cease to exist. Metaphysics has been, for centuries, arguing about what may have occurred, or must have occurred. Geology was an eye witness, and comes to tell us what did actually occur. Metaphysics has been laboring all her life to prove or disprove, that at some unknown former period some person must have made the watch and put it in the heath. Geology tells the day the watch was made and put there. She was perfectly acquainted with the heath when there was no such watch in existence, either there or anywhere else; and not only so, but she knows of many other watches, of strange workmanship, which have

lain in earlier times on the same heath, altogether unobserved by any Metaphysician. Of these also she can tell the date of manufacture. Thus, while Metaphysics has been trying in vain to determine whether or not watches were or could have been made at all, Geology gives a complete history of all the various styles of watches.

Of all other Physical sciences on the contrary, the tendency, at least until very lately, has been towards materialism. This is no disparagement of Physical science, for the exclusive study of almost any department necessarily leads to some form of false Philosophy. The study of the Mathematical and Metaphysical sciences, and the exclusive employment of the deductive methods, as certainly tends towards scepticism, as the study of the physical sciences, and the too exclusive employment of the inductive method, tends to materialism. The prevalence of the metaphysical spirit as naturally culminates in the Atheism of the last age, as the prevalence of the scientific spirit in the material Philosophy of the present. The Metaphysical age, full of its ingenuities and dexterities, fonder of sleight of hand than of useful strength, fighting for victory rather than for truth; the Metaphysical age, I repeat, is passing away, and with it the sneering, ingenious, negative scepticism to which it gave birth. But the scientific age is still in its vigor; an age more earnest and truth-loving; and with it comes also the more earnest, positive scepticism of the present day; a scepticism more respectable, but also all the more dangerous for its earnest and truth-seeking character. I think no one will deny the great danger of this form of scepticism at the present time. But only he who with deep anxiety has watched the strong

tendency of the age towards materialism—who has seen physical forces gradually usurping the place and power of Deity in the kingdom of nature, until the universe is governed by blind necessity instead of *will*—who has seen even the realm of organic nature invaded, and organization and life itself brought more and more under the dominion of physical and chemical forces, and even the human mind becoming the necessary result of organization—only he who has battled with this dreadful doubt—who has wrestled with this dragon of materialism—who has labored in thought for evidence wherewith to overthrow a philosophy so degrading to man, a philosophy which destroys his spirituality, his immortality, every noble upward striving of his nature, and who has nevertheless felt himself carried onward by the force of the logical current to the very verge of the precipice, in spite of his earnest and honest efforts to the contrary—I repeat, he and only he, is in a position to estimate the infinite service which Geology has done to the cause of religion and faith. He at least will hail Geology as a beacon light pointing the way of safety.

We smile with contempt at the absurd Polytheism of the Greeks, but there is a modern Polytheism not less degrading. The effect of study of physical science has been to make us all in a certain sense Polytheists. Instead of Jupiter, Neptune, Mars and Appollo, our Gods are now gravitation, electricity, chemical affinity. It is almost impossible for many to think of these so-called secondary causes except as efficient agents, controlling and producing all the phenomena of the universe. Thus secondary causes, like a cloud, have gotten between us and the great First Cause, and shut out the light from our

souls. Geology alone, by the indisputable evidence she gives of the direct agency of a First Cause, is clearing away the clouds, and restoring us to the light and warmth so necessary to spiritual life.

I know that Geology is looked upon by many with dread and suspicion as the enemy of faith. It is true that by collision with theology it has seemed to be opposed to Scripture—in overthrowing the human interpretation it has seemed to strike at the Divine essence. It is true that it has thus unsettled the faith of many whose faith was never very strong, and weakened the influence of others whose faith in their own prejudices is much stronger than their love of truth. It is true that infidelity has made use of this as well as of every other science, physical or metaphysical, to impugn the truth of revelation. It is true, alas! too true—that in many ways much evil has been the result. But the history of Science proves that this collision is only apparent, and the evil therefore transitory, while the service is real and lasting. The former will be removed, the latter only confirmed by time. Thirty years more and Geology will be universally acknowledged as the chief handmaid of religion among the sciences. One generation more passed away, and all defence of Geology is unnecessary. But time alone can accomplish this. At least one generation has yet to pass away.

Perhaps it may seem to some a startling paradox, but it is nevertheless an undoubted fact, that the shortness of human life is one of the most powerful elements of human progress. It would seem as if the human mind grows and developes—the philosophy and opinions which govern the conduct of life continue to be modified and

moulded, until the age of about twenty-five or thirty, when our characters become unchangeable, our opinions become prejudices, and the whole mind petrified. Farther progress would be impossible, but that another generation with minds still plastic comes forward, takes up and carries on the work a few steps, and becomes petrified in its turn. There are certainly some noble exceptions to this rule—instances of minds which with their maturity retain the plasticity of youth; but the very rarity of the exception only proves the rule.

You doubtless recollect that the children of Israël wandered forty years in the wilderness before they were fit to enter the promised land. The marks of Egyptian bondage were upon their souls as well as upon their necks. One generation must fall in the wilderness, and a new generation, free from Egyptian prejudices, must arise. We are apt to look upon this as an isolated fact and characteristic of this very peculiar people. On the contrary, it is a fact of the deepest significance in the philosophy of human progress. To this day it seems impossible that any great step should be made in the intellectual progress of our race, except by the sacrifice of at least one generation. We are even now in the midst of such a great change, brought about by the revelations of Geology. One more generation dropped in the wilderness, and we are fairly in the promised land.

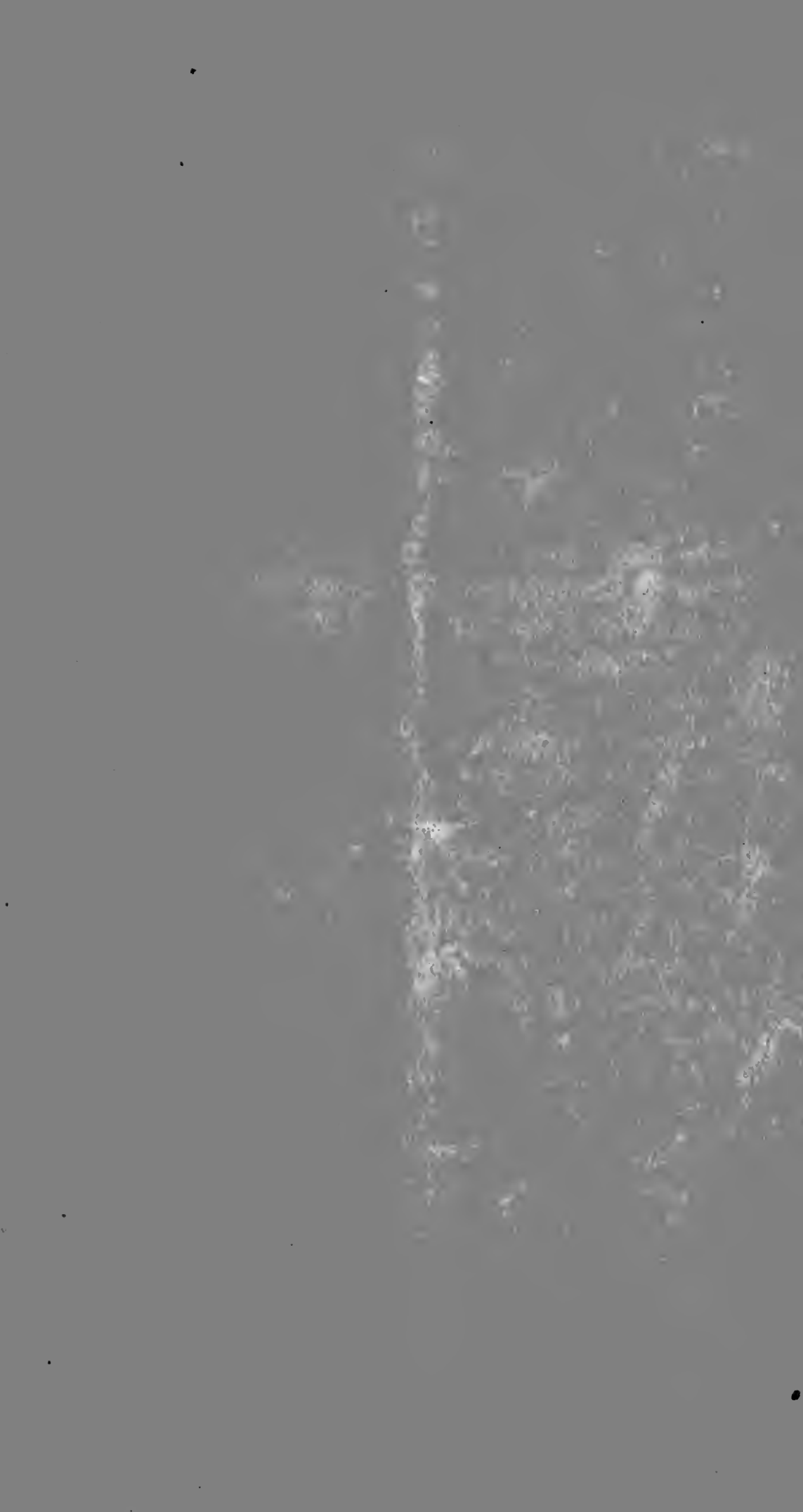
Science, Art, Religion. Three great rivers of unknown length—emptying into the same ocean of *infinite truth*. All human culture consists in the exploration of these streams. Commencing with their extreme and widely separated tributaries, we have as yet explored but an

infinitely small portion of each ; and because in their devious course and judging by our poor and imperfect compasses, they seem sometimes to diverge, in our pride and presumption we hastily conclude that they never converge again, that they are entirely distinct and even antagonistic. But the day is not far distant I trust—I believe it is already dawning—when the close relationship of these three will be recognized by all—when they shall no longer be looked upon as enemies, but as co-workers in the great design of Providence, the restoration of the pristine harmony and beauty of man's intellectual and moral nature. But, alas ! instead of this co-operation, we find unnatural divorce or even open hostility, and the enemy, taking advantage of their divided and weakened forces has succeeded, to some extent at least, in degrading all from their high function as teachers, to become the slaves of man. *Science* instead of being revered as the human interpretation of Divine thoughts and plans, the incarnation of Divine wisdom, is valued only as an useful servant contributing to our physical necessities ; as a means of clothing, feeding and bearing us about. *Art* instead of being loved with enthusiasm as the human form of Divine harmony and beauty, is regarded only as a means of sensuous enjoyment. Even Religion comes to be regarded only as a political engine to effect the selfish purposes of despots or intriguers ; or at least as a weak superstition, intended only to overawe the ignorant and vicious ; an ingenious device whereby to manufacture peaceable citizens and good children.

This unnatural separation cannot always exist. They must again be united. Then it will be seen that there

is a holiness in Beauty as well as a beauty in Holiness—a *goodness* in true wisdom as well as a *wisdom* in goodness. Science, Religion and Art, shall become a glorious trinity, striving together to bring man to the apprehension of that still more glorious Trinity of which they are the *human type*.





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